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SPECIFICATION OF INVENTION
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(75) S.A. Chekcheev
(56) Temarinac M., Markovic A., and Zivkovic-Drunja, MF-AM Stereo Broadcasting: The Choice of Modulation. // IEEE Transactions on Broad. - Mar. 1989 - Vol. 35, p. 79-87

(54) SYSTEM FOR STEREO BROADCASTING

(57) The invention relates to radio communication and can be utilized for building up stereo radio broadcasting systems operated in the amplitude modulation mode, and also for having radio stereo broadcasting in networks of multiple-program wire broadcasting. The object of the invention is to provide for compatibility with mono receivers, and also to mitigate crosstalk distortion. The system comprises a radio transmitter device including one sum/difference converter, two amplifiers. four Gilbert converters, two lower-frequency filters, four multipliers, two sine voltage generators, two amplitude detectors, three adders; and also a radio receiver device including one high and intermediate frequency section, two bandpass filters, two amplitude detectors, one sum/difference converter, and two lower-frequency filters.
2 drawings.

The invention relates to radio communication and can be utilized for building up stereo radio broadcasting systems operated in the amplitude modulation mode, and also for having radio stereo broadcasting in networks of multiple-program wire broadcasting.

There is known a stereo broadcasting system comprising a transmitter device including the first and second limiting amplifiers having their outputs connected to the first inputs of the first and second adders whose second inputs are connected via the first and second square root extractors to the first and second inputs of a quadrature modulator whose output is connected via a strict limiter to the radio frequency (RF) input of an amplitude modulator, and via a square-law amplitude detector to the modulation input of the amplitude modulator; and a receiver device including an RF section whose output is connected to the first input of a multiplier whose output is connected via a bandpass filter tuned to a frequency equaling the double intermediate frequency to the first input of the second multiplier whose second input is connected to its output

via a first lower-frequency filter (LFF) and a variable oscillator, and whose output is connected via a second LFF to the first input of a matrix for producing L and R signals from L+R and L-R signals, and whose second input is connected to the output of the second multiplier via a third LFF.

The shortcomings of this known stereo broadcasting system are its incompatibility with mono receivers, and the presence of crosstalk distortion across the channels.

There is further known a stereo broadcasting system held as the closest prior art of this invention, comprising a radio transmitter device including a sum/difference converter (SDC), a first multiplier whose first input is connected to the difference output of the SDC, and whose second input is connected to the output of the carrier signal source, an adder whose first input is connected to the output of the first multiplier and whose second input is connected to the carrier signal source via a 90° phase shifter, a limiter whose first input is connected to the output of the adder and whose output is connected to the first input of a second multiplier whose second input is connected to the sum output of the SDC, and whose output is connected to the output of the device; and a stereo radio receiver device including high and intermediate frequency sections and a SDC, with the first input of the SDC connected to the output of the intermediate frequency section via an amplitude detector, and with the second input of the SDC being connected to the output of the intermediate frequency section via a difference signal extraction circuit.

The shortcomings of this closest prior art are likewise its incompatibility with mono receivers, and presence of crosstalk distortion across the channels.

It is the object of this invention to provide for compatibility with mono receivers and to mitigate crosstalk distortion.

This object is attained in a stereo broadcasting system comprising a radio receiver device including a high frequency and intermediate frequency (HF-IF) section and a sum/difference converter (SDC) whose first input is connected to the output of an amplitude detector, and a radio transmitter device including a SDC whose outputs *[sic!]*[1] are the inputs of the radio transmitter device, and also an adding device, wherein the radio receiver device includes an additional bandpass filter whose input is connected to the output of the HF-IF section, a second amplitude detector whose input is connected to the output of the additional bandpass filter and whose output is connected to the second input of the SDC, and also first and second lower-frequency filters (LFFs) whose inputs are connected to the sum and difference outputs of the SDC, and whose outputs serve as the outputs of the radio receiver device, with the radio transmitter device having the inputs of the adding device connected to the outputs of the SDC via extra circuits containing each an amplifier whose non-inverting input is connected to the output of the SDC, a first Gilbert converter whose input is connected to the output of the amplifier, a second Gilbert converter, a first multiplier whose first and second inputs are connected to the outputs of the first and second Gilbert converters, a sine voltage generator whose first input is connected to the input of the first Gilbert converter, a second multiplier whose first input is connected to the input of the second Gilbert converter, a second multiplier *[sic!]* whose first input is connected to the output of the amplifier and whose second input is connected to the sine voltage generator, an adder whose first and second inputs are connected to the outputs of the first and second multipliers, an amplitude detector and LFFs wired in series between the output of the adder and the inverting input of the amplifier, with the output of the adder being connected to the input of the adding device.

[1] This summing up in the original document of the claimed system is different in some places from the Claim - *[Translator's Note]*.

Fig. 1 presents a block-unit diagram of the radio transmitter device of the invention; and Fig. 2 presents a block-unit diagram of the radio receiver device of the invention.

Denoted with numerals in Figs. 1 and 2 are: 1, 26 - sum/difference converters; 2, 3 - amplifiers; 4, 5, 9, 12 - Gilbert converters; 6, 15, 27, 28 - lower-frequency filters; 7, 10, 11, 14 - multipliers; 8, 13 - sine voltage generators; 16, 19, 24, 25 - amplitude detectors; 17, 18, 20 - adders; 21 - high and intermediate frequency section; 22, 23 - bandpass filters.

The principle of operation of the radio transmitter device of the invention is as follows.

Signals S_L and S_R of the left and right stereo channels are fed to the input of the SDC 1. Signals $1+S_L+S_R$ and $1+S_L-S_R$ are fed from the outputs of the SDC 1 to the inverting inputs of the amplifiers 2 and 3 of the top and bottom (in the diagram) channels.

Let us consider separately the operation of the top channel, denoting the signal at the output of the amplifier 2 as $V_{L+R}(t)$. The Gilbert converter whose input is connected to the output of the amplifier 2 performs inverse Gilbert conversion; therefore, the signal at its output will be described as $-G(V_{L+R}(t))$ where G is direct Gilbert conversion.

The signals at the outputs of the multipliers of this channel will be, respectively:

$$U_{R1} = V_{L+R}(t) \cos \omega t, \text{ and} \tag{1}$$
$$U_{R2} = - G (V_{L+R}(t)) \sin \omega t , \tag{2}$$

where ω is frequency of the generator (oscillator) 8.

Given (1) and (2), the signal at the output of the adder 17 will be:

$$U_A = U_{R1} + U_{R2} = V_{L+R}(t) \cos \omega t - G (V_{L+R}(t)) \sin \omega t.$$

This signal U_A will be fed to the input of the amplitude detector 15. The output signal of the amplitude detector 15 will be determined by formula:

$$U_{AD} = \sqrt{U_A^2 + G^2(U_A)} = ((V_{L+R}(t) \cos \omega t - G(V_{L+R}(t)) \sin \omega t)^2 + G^2 ((V_{L+R}(t) \cos \omega t - G(V_{L+R}(t) \sin \omega t))^{1/2} \tag{4}$$

After the conversions, the final result will be:

$$U_{AD} = \sqrt{V_{L+R}(t) + G^2(V_{L+R}(t))} \tag{5}$$

This U_{AD} signal will be fed from the output of the amplitude detector to the input of the LFF 6 whose cutoff frequency has been selected to equal Ω_{max}. The output signal of the LFF 6 will be described by expression:

$$U_{LFF} = \frac{1}{2\pi} \int_{\Omega\max}^{\Omega\max} e^{i\omega t} [\int_{\infty}^{\infty} e^{i\omega x} U_{AD}(x) dx] d\omega = \frac{1}{2\pi} \int_{\Omega\max}^{\Omega\max} e^{-i\omega t} [\int_{\infty}^{\infty} e^{-i\omega x} \sqrt{V_{L+R}^2(x) + G^2(V_{L+R}(x)} dx] d\omega \tag{6}$$

With an adequately great amplification factor of the amplifier 2, the following equality will be true:

$$U_{LFF} = 1 + S_L + S_R \tag{7}$$

Then, given (6), the following can be affirmed:

$$\frac{1}{2\pi} \int_{\Omega\max}^{\Omega\max} e^{i\omega t} [\int_{\infty}^{\infty} e^{-i\omega x} \sqrt{V_{L+R}^2(x) + G^2(V_{L+R}(x)} dx] d\omega = 1 + S_L(t) + S_R(t) \tag{8}$$

It can be seen from (8) that the spectrum of the envelope of signal (3) within the frequency range of the complex spectrum [$-\Omega_{max}$, Ω_{max}] will coincide with the spectrum of audio signal 1 $+S_L + S_R$. This asserts the attainability of undistorted reception of signal (3) by a mono radio receiver. This attainability of undistorted reception of signal (3) by a mono radio receiver is further supported by the fact that the spectrum width of signal V_{L+R} is confined to value Ω_{max}. To prove this assertion, we can proceed with:

$$V_{L+R} = K\,(1 + S_L + S_R - U_{LFF})\,, \qquad (9)$$

where K is the amplification factor of the amplifier 2.

The functions S_L, S_R and U_{LFF} in expression (9) have their complex spectra belonging to the frequency range [$-\Omega_{max}$, Ω_{max}]. Hence, the following is true:

$$\frac{1}{2\pi}\int_{\Omega max}^{\Omega max} e^{|\omega t}[\int_{\infty}^{\infty} e^{-|\omega x} \text{ x } V_{L+R}(x)]d\omega = V_{L+R}\,(t)\,, \qquad (10)$$

which validates the actual spectrum width of signal (3) being limited by value Ω_{max}.

The bottom (in the diagram) channel of the transmitter device differs from the top one in that its generator 13 is tuned to a frequency exceeding the frequency of the top channel generator 8 by the width of the stereo signal spectrum Ω_{max}. Moreover, both Gilbert converters of the bottom channel perform direct Gilbert conversion. This provides for distancing by frequency the sum and difference channels, which brings down substantially crosstalk distortion across the channels.

The stereo radio receiver device illustrated in Fig. 2 operates as follows. An intermediate frequency radio signal is fed from the high and intermediate frequency section 21 output to the inputs of the intermediate frequency filters 22 and 23 whose respective central tuning frequencies are shifted through Ω_{max} relative to each other. In this, the signal envelope at the output of one of the filters corresponds to the sum signal, and at the output of the other one, to the difference signal. Hence, extraction of the envelopes by the detectors 24 and 25 with subsequent sum/difference conversion in the unit 26 allows to perform reconstruction of the signals of the left and right stereo channels. The lower-frequency filters 27 and 28 effect suppression of the signal harmonics above the Ω_{max} frequency. However, such filters can be omitted in receivers of a less expensive variety.

The technical and economic advantages of the claimed technical solution are brought about by the fact that its implementation enables to proceed with stereo broadcasting in decameter wave bands without impairing the quality of mono reception.

What is claimed is:

A stereo broadcasting system comprising a radio receiver device including a high frequency and intermediate frequency (HF-IF) section, an amplitude detector whose input is connected through a bandpass filter to the output of the HF-IF section, and a sum/difference converter (SDC) whose first input is connected to the output of the amplitude detector; and a radio transmitter device including a SDC whose inputs are the inputs of the radio transmitter device, and also an adding device, **characterized in that**, in order to provide for compatibility with mono radio receivers and to mitigate crosstalk distortion, the radio receiver device includes an additional bandpass filter whose input is connected to the output of the HF-IF section, a second amplitude detector whose input is connected to the output of the additional bandpass filter and whose output is connected to the second input of the SDC, and also first and second lower-frequency filters (LFFs) whose inputs are connected to the sum and difference outputs of the SDC, and whose outputs serve as the outputs of the radio receiver device; with the radio transmitter device having the inputs of the adding device connected to the outputs of the SDC via extra circuits containing each an amplifier whose non-inverting input is connected to the

output of the SDC, a first Gilbert converter whose input is connected to the output of the amplifier, a second Gilbert converter, a first multiplier whose first and second inputs are connected to the outputs of the first and second Gilbert converters, a sine voltage generator whose first input is connected to the input of the second Gilbert converter, a second multiplier whose first input is connected to the output of the amplifier and whose second input is connected to the sine voltage generator, an adder whose first and second inputs are connected to the outputs of the first and second multipliers, an amplitude detector and LFFs wired in series between the outputs of the adder and the inverting input of the amplifier, with the output of the adder being connected to the input of the adding device.

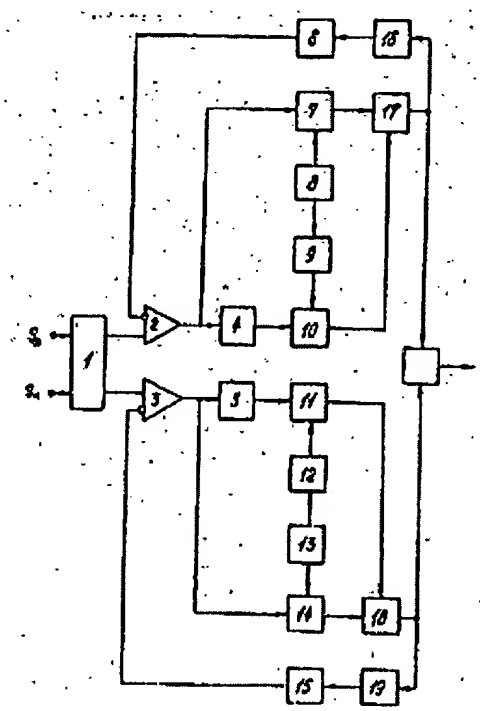

Fig. 1

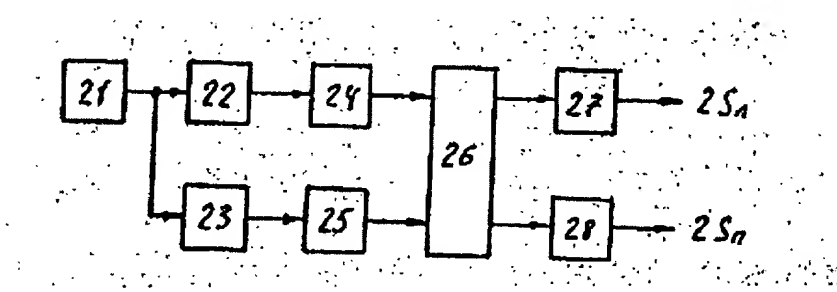

Fig. 2